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UNDERGRADUATE-PILOT-TRAINING DUTY SCHEDULES AND AIRCREW FATIGUE

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Stephen M. Rokicki, Ph.D.

William F. Storm, Ph.D.

Murray L. Durant, Airman First Class, USAF

Richard J. Fulton, Captain, USAF (Reese Air Force Base, Texas)

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235



NOTICES

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The operational personnel who participated in this study were fully briefed on all procedures prior to participation in the study.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.



STEPHEN M. ROKICKI, Ph.D.
Project Scientist



WILLIAM F. STORM, Ph.D.
Supervisor



ROY L. DEHART
Colonel, USAF, MC
Commander

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performance deterioration is more apt to occur in new, unmastered tasks, and UPT is a learning situation for the students. Beginning the early-week duty days a little later (0630-0700) may result in a notable reduction in early-morning pilot fatigue and sleepiness. At minimum, the findings provide empirical data for instructing the pilots on the importance of acquiring adequate sleep.

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UNDERGRADUATE-PILOT-TRAINING DUTY SCHEDULES AND AIRCREW FATIGUE

INTRODUCTION

During the 50 weeks of USAF undergraduate pilot training (UPT), instructors and students alternate weekly between an early-reporting and late-reporting daily work schedule. This split schedule permits maximum use of aircraft and assures adequate exposure to nighttime flying as the students progress through phases of training. The early schedule requires a reporting time of about 0530, while those on the late schedule report from 1030-1230. Most training occurs during the standard 5-day work week, and a typical day includes both academic instruction and flight training. At the request of the Safety Office of the 64th Flying Training Wing (ATC), Reese AFB, Texas, the Crew Performance Branch of the USAF School of Aerospace Medicine (USAFSAM/VNE) conducted an exploratory study* to evaluate the effects of the alternating weekly schedule on pilot fatigue and sleep schedules.

METHOD

The Subjective Fatigue Checkcard (SAM Form 136) and the Sleep Survey (SAM Form 154) have been used successfully to evaluate crew stress and fatigue in a variety of airborne and ground operations (3-6,11,12). These self-administered surveys have been selected and developed to minimize interference with operational duties, daily schedules, and personal activities. The Sleep Survey (Fig. 1) documents the hours slept during each 24-hour period and requires about 1 minute to complete. The Subjective Fatigue Checkcard (Fig. 2) can be completed in less than a minute and results in a score ranging from 0-20 (arbitrary units), with lower scores indicating greater fatigue (10). In general, subjective fatigue scores above 11 indicate feelings of alertness, scores of 11 to 8 relate mild to moderate fatigue, and scores of 7 and below indicate severe fatigue.

Prior to the study, all participants were briefed on the purpose, procedure, and data collection schedule for both surveys so that individuals could assume responsibility for the proper and timely collection of their own data. The large ratio of participants to investigators, the individual schedule of each participant, and the need for some at-home data collection made a self-administrative methodology practical and efficient.

Fifty-five student and instructor pilots assigned to the 35th (T-37 aircraft) or the 54th (T-38 aircraft) Flying Training Squadrons participated in the study. Each participant was directed to complete a Sleep Survey and an initial Subjective Fatigue Checkcard each day within an hour or so of arising.

*Data collection (July-August 1980) was monitored by Captain Richard J. Fulton of the Training Wing.

SLEEP SURVEY		GRADE	DATE/TIME
NAME (Last, First, MI)	TIME (Min.)		
<p>1. On the chart below, mark an X in each half hour interval you slept yesterday and today.</p>			
<p>YESTERDAY</p>			
<p>1100 1120 1140 1150 1155 1158 1159 1200 1210 1220 1225 1228 1229 1230 1235 1238 1239 1240 1245 1248 1249 1250 1255 1258 1259 1300 1310 1320 1325 1328 1329 1330 1335 1338 1339 1340 1345 1348 1349 1350 1355 1358 1359 1400 1410 1420 1425 1428 1429 1430 1435 1438 1439 1440 1445 1448 1449 1450 1455 1458 1459 1500 1510 1520 1525 1528 1529 1530 1535 1538 1539 1540 1545 1548 1549 1550 1555 1558 1559 1600 1610 1620 1625 1628 1629 1630 1635 1638 1639 1640 1645 1648 1649 1650 1655 1658 1659 1700 1710 1720 1725 1728 1729 1730 1735 1738 1739 1740 1745 1748 1749 1750 1755 1758 1759 1800 1810 1820 1825 1828 1829 1830 1835 1838 1839 1840 1845 1848 1849 1850 1855 1858 1859 1900 1910 1920 1925 1928 1929 1930 1935 1938 1939 1940 1945 1948 1949 1950 1955 1958 1959 2000 2010 2020 2025 2028 2029 2030 2035 2038 2039 2040 2045 2048 2049 2050 2055 2058 2059 2100 2110 2120 2125 2128 2129 2130 2135 2138 2139 2140 2145 2148 2149 2150 2155 2158 2159 2200 2210 2220 2225 2228 2229 2230 2235 2238 2239 2240 2245 2248 2249 2250 2255 2258 2259 2300 2310 2320 2325 2328 2329 2330 2335 2338 2339 2340 2345 2348 2349 2350 2355 2358 2359 2400 2410 2420 2425 2428 2429 2430 2435 2438 2439 2440 2445 2448 2449 2450 2455 2458 2459 2500 2510 2520 2525 2528 2529 2530 2535 2538 2539 2540 2545 2548 2549 2550 2555 2558 2559 2600 2610 2620 2625 2628 2629 2630 2635 2638 2639 2640 2645 2648 2649 2650 2655 2658 2659 2700 2710 2720 2725 2728 2729 2730 2735 2738 2739 2740 2745 2748 2749 2750 2755 2758 2759 2800 2810 2820 2825 2828 2829 2830 2835 2838 2839 2840 2845 2848 2849 2850 2855 2858 2859 2900 2910 2920 2925 2928 2929 2930 2935 2938 2939 2940 2945 2948 2949 2950 2955 2958 2959 3000 3010 3020 3025 3028 3029 3030 3035 3038 3039 3040 3045 3048 3049 3050 3055 3058 3059 3100 3110 3120 3125 3128 3129 3130 3135 3138 3139 3140 3145 3148 3149 3150 3155 3158 3159 3200 3210 3220 3225 3228 3229 3230 3235 3238 3239 3240 3245 3248 3249 3250 3255 3258 3259 3300 3310 3320 3325 3328 3329 3330 3335 3338 3339 3340 3345 3348 3349 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Figure 1. SAM Form 154: Sleep Survey.

NAME AND GRADE		TIME (DATE)		
INSTRUCTIONS Make one and only one 'x' for each of the ten items. Think carefully about how you feel RIGHT NOW .				
STATEMENT	BETTER THAN	SAME AS	WORSE THAN	
1. VERY LIVELY				
2. EXTREMELY TIRED				
3. QUITE FRESH				
4. SLIGHTLY POOPED				
5. EXTREMELY PEPPY				
6. SOMEWHAT FRESH				
7. PETERED OUT				
8. VERY REFRESHED				
9. FAIRLY WELL POOPED				
10. READY TO DROP				

SAM FORM 136
SEP 76

SUBJECTIVE FATIGUE CHECKCARD

PREVIOUS EDITION WILL BE USED

Figure 2. SAM Form 136: Subjective Fatigue Checkcard. Lower scores indicate greater fatigue.

For the remainder of the day, additional fatigue checkcards were to be self-administered upon completion of each major training activity, which was anticipated to be about once every 4 hours. Sleep and fatigue data were collected daily for 4 successive weeks, including weekends and other off-duty days. As on training days, fatigue checkcards were to be completed about every 4 hours during off-duty days.

During the prestudy briefing, 41 of the 55 participants responded to a time-of-day preference questionnaire (7). This instrument classifies an individual as being one of five types: (1) definite or (2) moderate morning type; (3) definite or (4) moderate evening type; or (5) neither type. This time-of-day preference measure had not been previously used by USAFSAM/VNE. For this study, extreme time-of-day preferences were considered as possible factors in individual reactions to the early/late training schedule and therefore of possible value in interpreting the subjective fatigue and sleep data.

RESULTS

Only a few of the 55 participants reported complete data for every day of the study. Emergency leaves, illness, cross-country sorties, and most frequently, forgetting, all contributed to the occurrence of missing data. The data from some participants were so meager that they had to be completely discarded. Because of missing data, mean values presented for comparisons in

tables and graphs were not always calculated on the same participants and varied as to sample size. In general, the results presented are based on data from participants who submitted an initial and an end-of-day fatigue checkcard for at least 1 work week.

Time-of-Day Preference

Distribution of time-of-day preferences for T-37 and T-38 participants is summarized in Table 1. Of 41 respondents, 26 (63%) reported no morning nor evening preference, and none of the 41 could be classified at the extremes as definite morning or evening types. In the T-37 group, 8 of 22 respondents were moderate morning types; in the T-38 group, only 3 of 19. While these data are of general interest, the absence of extreme preferences made it impractical to further evaluate the relationship between time-of-day preferences and sleep or fatigue scores in this study.

TABLE 1. NUMBER OF PILOTS CLASSIFIED IN EACH TIME-OF-DAY PREFERENCE CATEGORY

Category	T-37	T-38	Total
Definite morning type	0	0	0
Moderate morning type	8	3	11
Neither type	12	14	26
Moderate evening type	2	2	4
Definite evening type	0	0	0
TOTAL	22	19	41

Sleep

The mean number of hours slept each night of the week by student and instructor pilots when on the early and late schedules are presented in Figure 3. These data are further summarized in Table 2 for nights preceding duty and nonduty days.

In general, pilots (students and instructors) in both aircraft (combined) acquired 6.8 hours of sleep per night during the work week when on the early schedule and 8.6 hours when on the late schedule. On the two weekend nights, pilots coming off the early schedule reported an average of 9.5 hours per night, and those coming off the late schedule, 9.0 hours. The average weekend nightly sleep always increased more than 2 hours after an early work week. After a late work week the sleep increased less than 1 hour--except for the T-37 student group, who slept less on the weekend after a late work week than during that week.

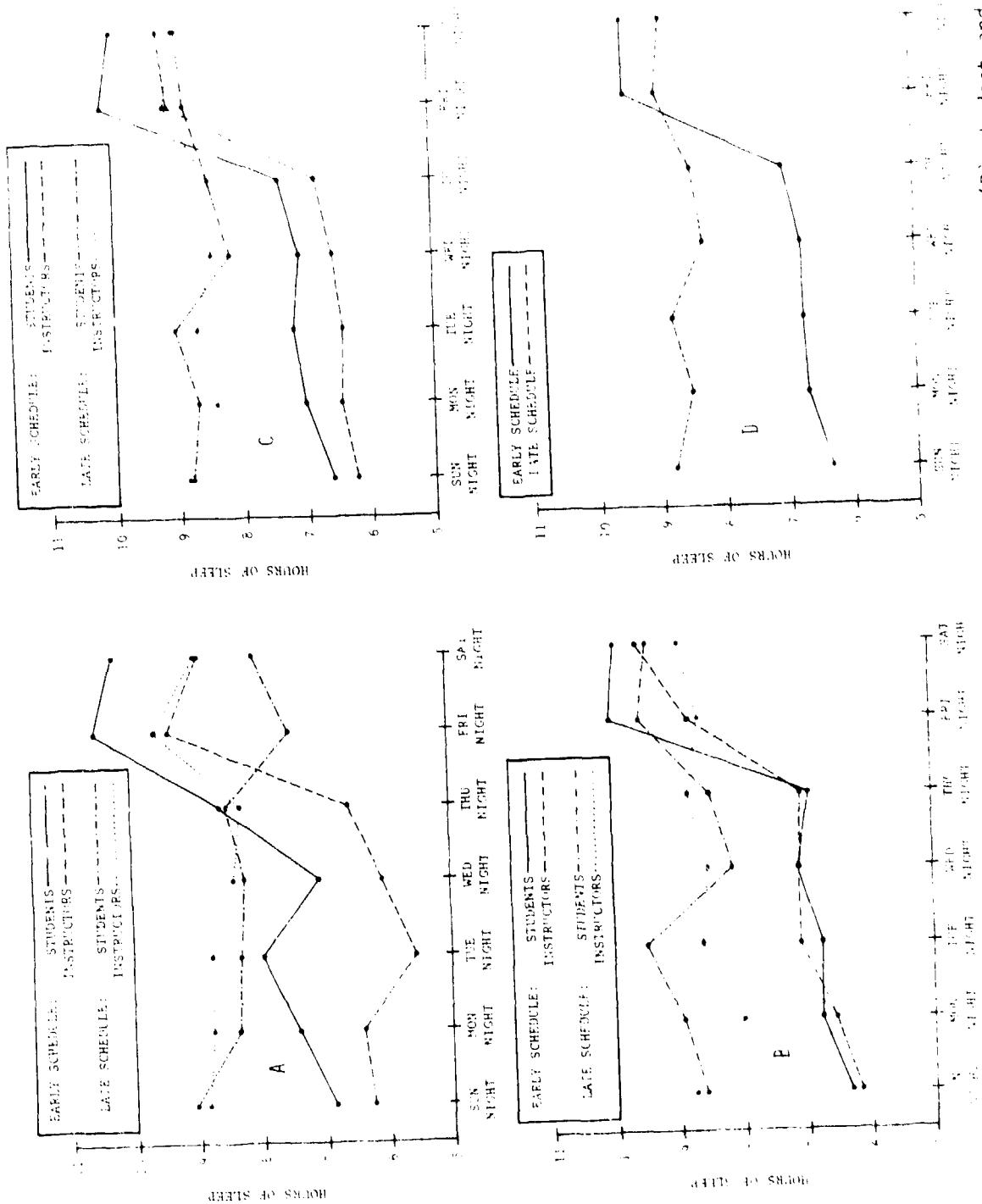


Figure 3. Mean hours slept each night by (A) student and instructor T-37 pilots; (B) student and instructor T-38 pilots, (C) all student and instructor pilots, T-37 and T-38 combined; (D) all pilots combined.

TABLE 2. AVERAGE HOURS SLEPT/NIGHT FOR NIGHTS PRECEDING DUTY DAYS (A) AND WEEKEND DAYS (B), AND ALL 7 NIGHTS COMBINED (C)

	<u>Early</u>			<u>Late</u>		
	<u>A</u>	<u>B</u>	<u>C</u>	<u>A</u>	<u>B</u>	<u>C</u>
<u>T-37</u>						
Student	7.6	10.4	8.4			
Instructor	6.2	9.1	7.1	8.5	7.8	8.3
				8.6	9.3	8.8
<u>T-38</u>						
Student	6.8	10.0	7.7			
Instructor	6.8	9.2	7.5	8.7	9.5	9.0
				8.6	8.8	8.6
<u>T-37 and T-38 Combined</u>						
Students &	6.8	9.5	7.5			
Instructors				8.6	9.0	8.7
(combined)						

Much of the variability in the T-37 and T-38 data presented in Figure 3 (A and B) may be a result of the small sample sizes (in most cases $n < 20$) on which the means were calculated. Because the T-37 and T-38 sleep data demonstrated similar patterns, increased stability in the means could be achieved by combining the data across aircraft types to produce the more discriminating presentation in Figure 3(C). Here the similarities in the student and instructor sleep patterns, and the differences in the patterns for the early versus late schedules, are apparent. By again combining the data across student and instructor pilots, the different weekly sleep patterns relating to the early and late schedules are singularly presented in Figure 3(D).

Bedtimes and arising times were evaluated to determine when the participants were reducing their sleep time when assigned to the early schedule. Mean bedtimes and rising times are presented in Figure 4 for instructors and students in each squadron and for combined squadrons and pilots. Figure 4 shows that on nights preceding duty days the instructors and students assigned to the early schedule retired about 1 1/2 hours earlier (except on Sunday nights), but arose over 3 hours earlier, than when on the late schedule.

To the sleep survey question "Do you feel like you could have used some more sleep?" 45 pilots responded in the affirmative. When arising on the early schedule, 18 (of 21) T-37 pilots and 18 (of 24) T-38 pilots felt that they needed more sleep at least 75% of the time. When arising on the late schedule, only 2 of the T-37 and 5 of the T-38 pilots felt the need for more sleep this frequently. (See Table 3.)

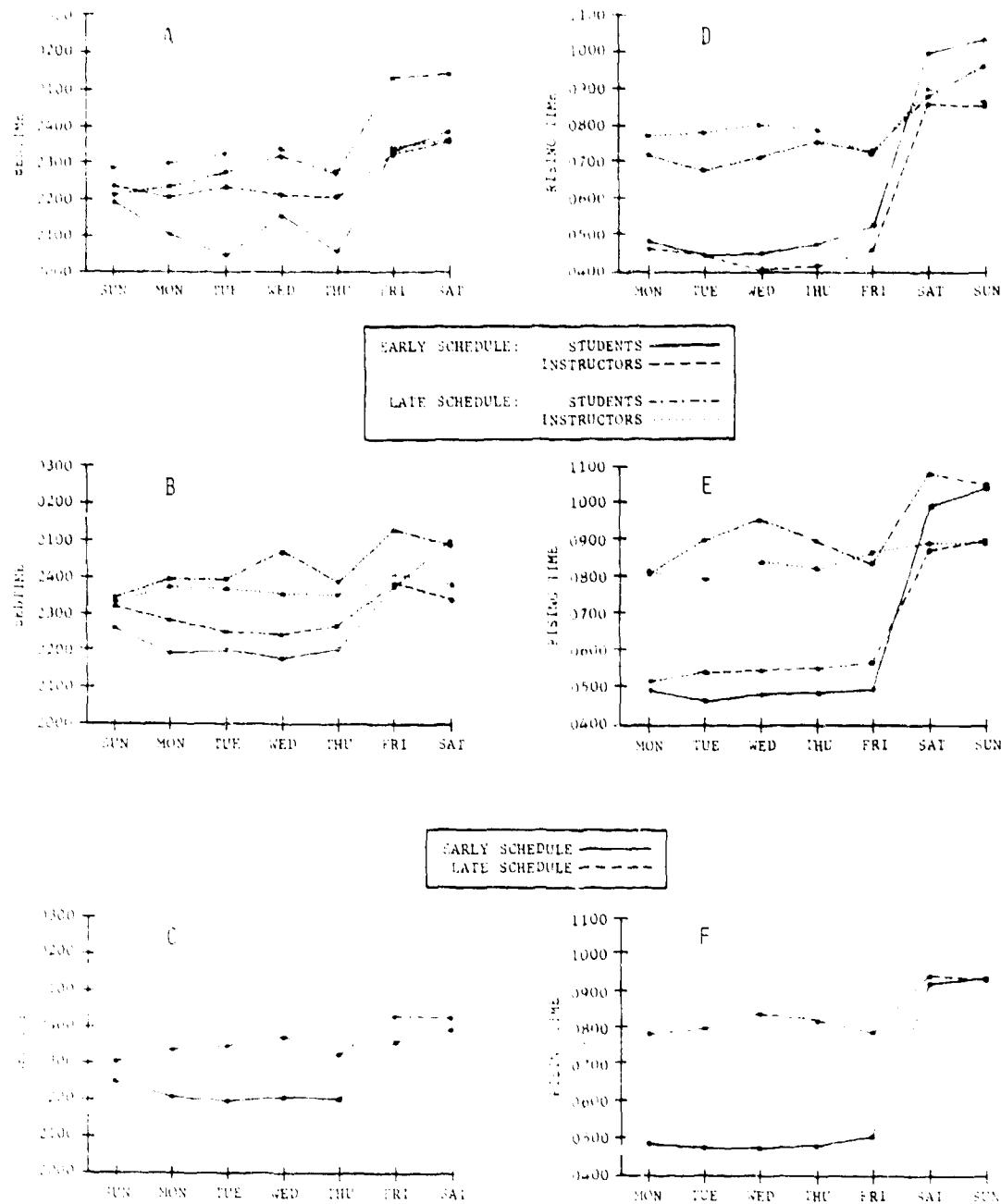


Figure 4. Mean daily bedtimes (A-C) and rising times (D-F) for:
 T-37 Pilots (A and D)
 T-38 Pilots (B and E)
 All pilots combined (C and F)

TABLE 3. NUMBER OF PILOTS DESIRING MORE SLEEP
UPON ARISING FOR DUTY

<u>Time more sleep needed</u>	<u>Schedule:</u>	<u>T-37 Pilots (21)</u>		<u>T-38 Pilots (24)</u>	
		<u>Early</u>	<u>Late</u>	<u>Early</u>	<u>Late</u>
100%		10	1	10	2
75-99%		8	1	8	3
50-74%		1	6	5	1
<49%		2	13	1	18

Subjective Fatigue

Collection of subjective fatigue scores was planned for about every 4 hours to permit analysis of progressive within-day changes. Too many data were missing to permit such an analysis; however, daily comparisons could be made between fatigue scores reported upon arising with those reported at the end of a duty day. Weekends were excluded because of missing data. Graphic summaries of the daily comparisons are presented in Figures 5A and 5B for the T-37 and T-38 participants, respectively, and in Figure 5C for all participants combined. Table 4 presents overall mean subjective fatigue scores for both schedules, complementing Figures 5A-5C.

The fatigue scores for pilots and instructors were fairly similar in both the T-37 and T-38 squadrons. As best summarized in Figure 5C and the bottom row of Table 4, an overall mean score of about 10, indicating mild fatigue, was reported at the start of a duty day on the early schedule while a score of about 13, reflecting feelings of alertness, was reported on the late schedule. At duty-day end under both schedules, average fatigue scores of about 8 were reported, indicating moderate fatigue. There were no apparent systematic day-to-day changes in the average fatigue scores reported across the days of the week.

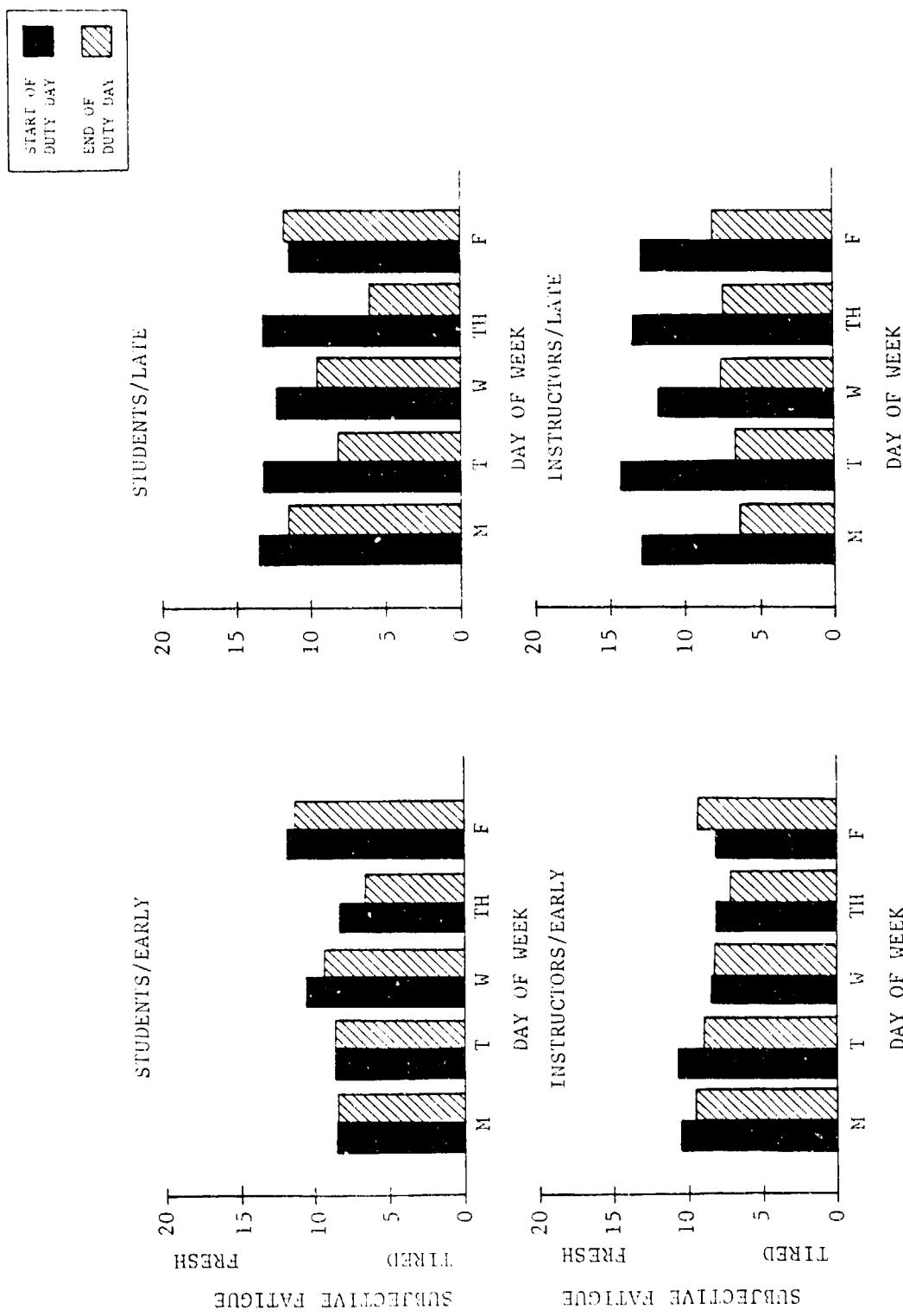


Figure 5A. Mean subjective fatigue scores for student and instructor T-37 pilots.

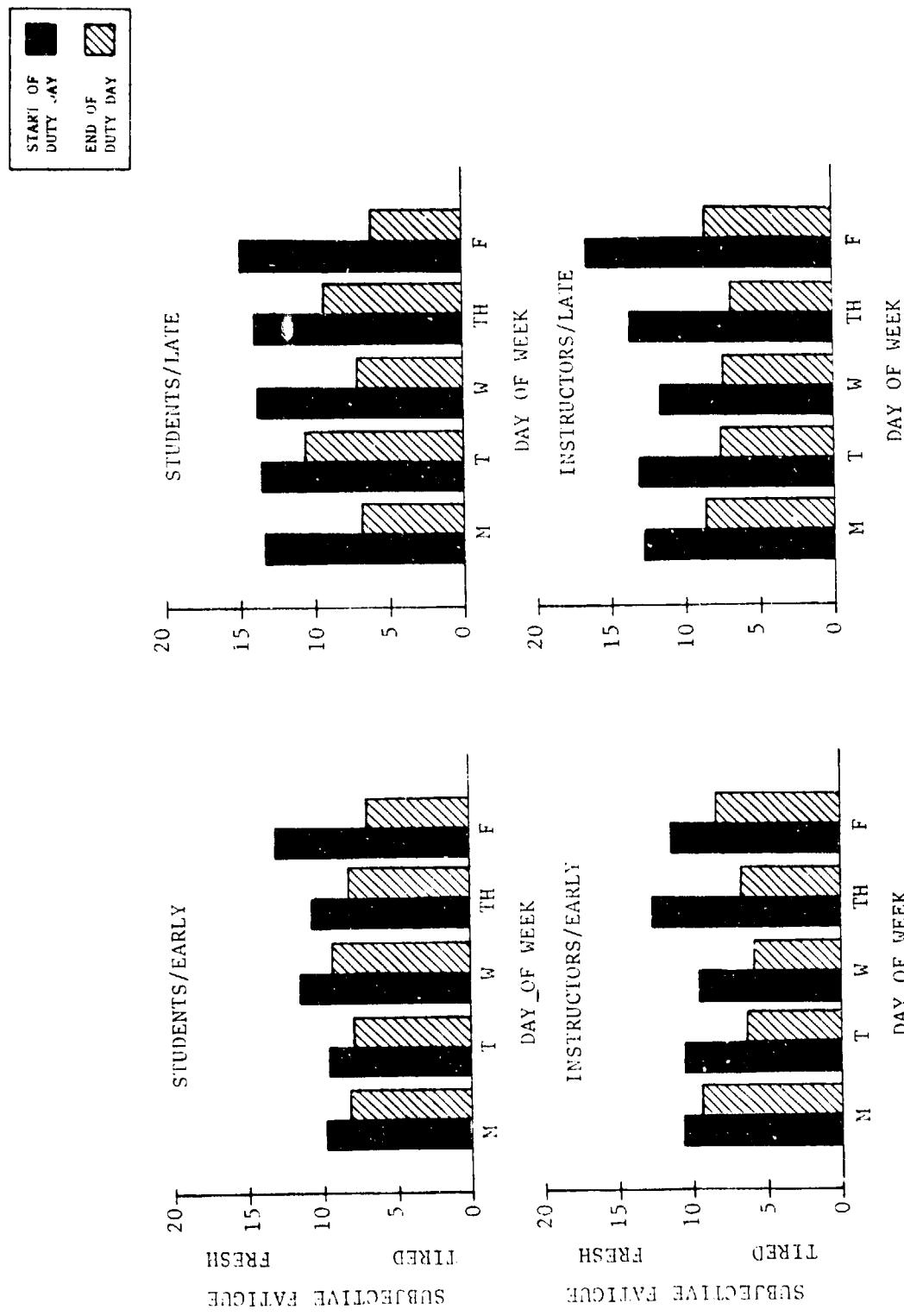


Figure 5B. Mean subjective fatigue scores for student and instructor T-38 pilots.

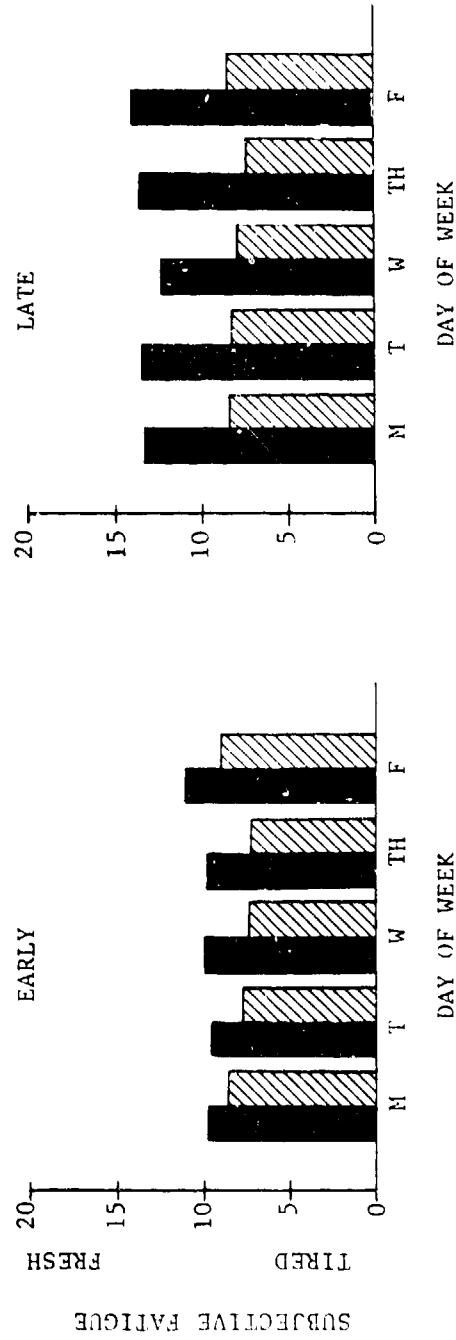


Figure 5C. Mean subjective fatigue scores for all pilots.

TABLE 4. OVERALL MEAN SUBJECTIVE FATIGUE SCORES REPORTED AT THE START AND END OF DUTY DAYS

Pilots	Schedule:	Early		Late	
		Duty Day:	Start	End	Start
<u>T-37 (N=20-40)</u>					
Students		9.5	8.8	12.6	9.4
Instructors		9.1	8.5	13.1	7.2
<u>T-38 (N=27-44)</u>					
Students		10.8	8.0	13.9	7.9
Instructors		10.9	7.2	13.5	7.7
<u>T-37 & T-38 (N=128-147)</u>					
Combined		10.1	8.0	13.3	8.0

Scores:

Above 11 = alert
 8-11 = moderate to mild fatigue
 7 and below = severe fatigue

DISCUSSION

Duty Days

Young, healthy adults working typical "8-5" daytime jobs acquire 7.5-8.0 hours of sleep each night of the work week (Sunday-Thursday nights) (9). Compared to this reference value, both student and instructor pilots acquired about 0.5-1.0 hour more sleep per night when assigned to the late schedule and forfeited about 1 hour of sleep per night when on the early schedule. These variations relate to the atypical UPT duty schedules.

Both student and instructor pilots made some attempt to adjust their sleeping times to the early schedule by going to bed more than 1 hour earlier than when on the late schedule, except for Sunday nights. Because of the very early arising time, however, they had a net loss in total hours slept. Associated with the early rising were subjective reports of a need for more sleep and subjective fatigue scores indicative of inadequate rest and sleep. In contrast, when on the late schedule, the pilots awoke feeling rested and reported fatigue scores consistent with those reported in previous studies by subjects arising from a full night of sleep (4).

The effects of partial sleep loss on fatigue and performance have been studied extensively, but findings have not been consistent. The extensive manipulations that can be made in sleep schedules and work/rest cycles

account for much of the variation in findings. Most people continue to function with minimal impairment during an abruptly induced restricted sleep regimen, and when the restriction is removed they return to their usual sleep schedule. They do not adapt to, nor do they prefer to continue, a restricted sleep schedule longer than necessary. In a laboratory study particularly relevant to this effort, daily hours slept by young adults were abruptly reduced from 8.0 (2330-0730) to 5.5 hours (0100-0630) per night for 60 days (13). The subjects' sleep-onset times decreased during the first week, then stabilized. Getting up in the morning was reported to be difficult during the entire 60 days, though the greatest difficulty was during the first week. Feelings of drowsiness also were most frequently reported during the first week. No performance decrements occurred in memory and problem-solving abilities, although a slight but significant decline did occur in auditory vigilance performance.

A few studies have evaluated the effects of gradually reducing (e.g., 0.5 hour every 2 weeks) nightly sleep to 4.5 hours (8,9). The subjects reduced their sleep by going to bed later; their time of getting up remained constant. In general, feelings of fatigue and the need for more sleep began to be reported when sleep was reduced by 1.0-1.5 hours. Performance was maintained on memory and problem-solving tasks but deteriorated somewhat on the auditory vigilance task. When the subjects returned to ad lib sleep regimens, they did not revert to sleeping 7-8 hours per night; instead, they required only 6.0-6.5 hours nightly. Feelings of fatigue appeared to set the lower limits for hours slept.

Over a 24-hour period, feelings of fatigue vary systematically, demonstrating a circadian rhythm just as reliable as those established for several physiological functions. The circadian rhythm in body temperature is one of the best documented for a physiological measure (1). Typical baseline circadian patterns for oral temperature and subjective fatigue data collected simultaneously from 16 subjects over a 3-day period are presented in Figure 6. The correspondence between the two baseline patterns is notable and well established. Similar within-day patterns of fatigue scores would likely have been demonstrated in the present study, for both the early and the late schedules, had data collection been more complete.

The early schedule tends to resist the typical daily temperature and subjective fatigue circadian patterns, whereas the late schedule is more compatible. A seemingly simple solution to overcome the reduced sleep reported when on the early schedule would be to encourage the pilots to advance their bedtimes even more to fully compensate for the early arising times. As depicted in Figure 6, however, this adjustment may not be physiologically feasible or desirable. Bedtimes as early as 2000 would interfere with study and social activities. Such bedtimes would also align with peak body temperature and subjective fatigue scores that reflect, respectively, a state of arousal and feelings of alertness. Furthermore, feelings of fatigue are greatest when body temperature is lowest, between 0300 and 0500--the time of day that the student and instructor pilots must awaken to report for an early-schedule duty day.

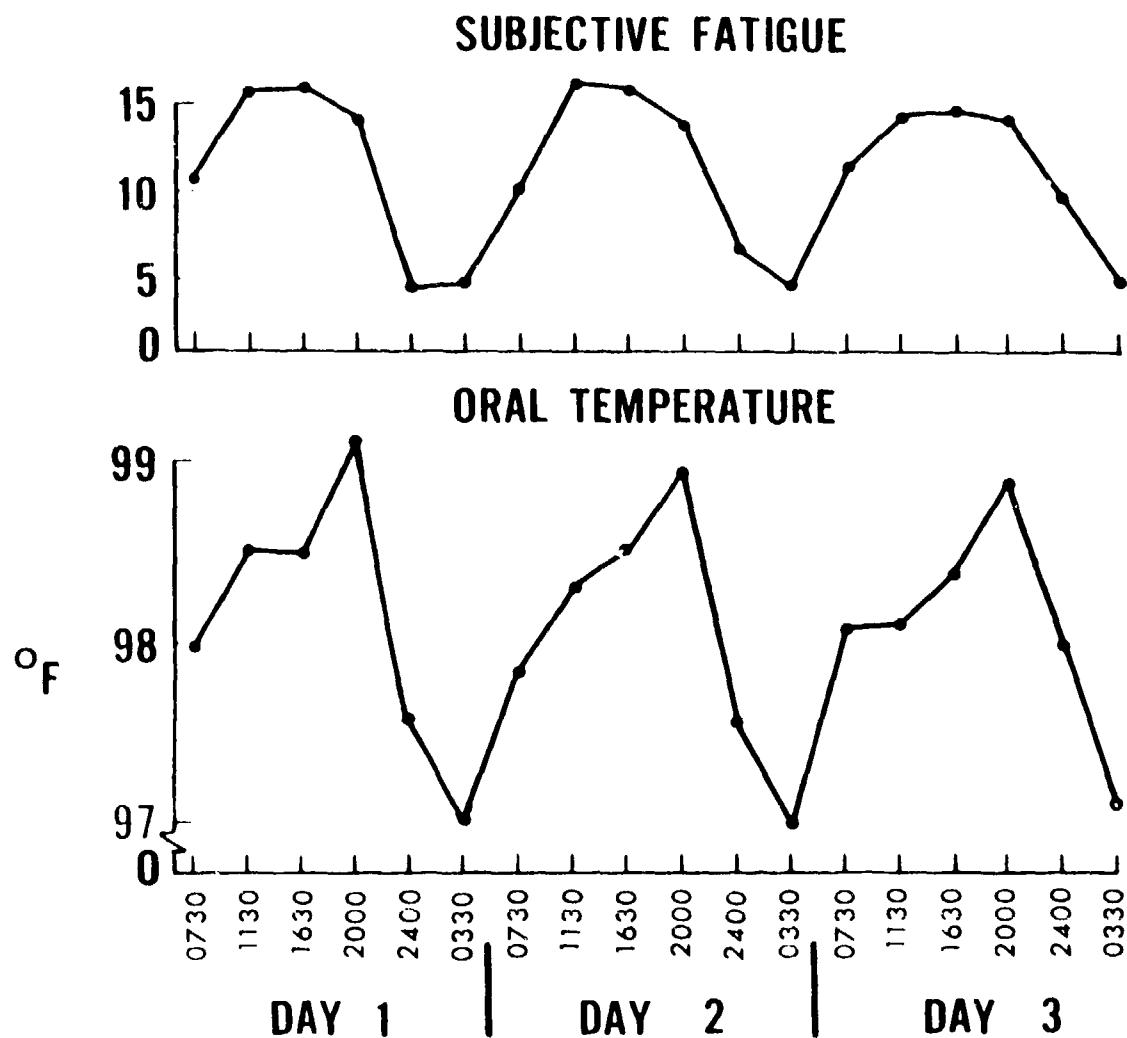


Figure 6. Typical circadian rhythms for subjective fatigue scores (from SAM Form 136) and oral temperature.

Weekend Days

The amount of sleep required to recover from a reduced sleep schedule is not linearly related to the amount of sleep deficit. Laboratory and operational studies have consistently demonstrated the dramatic recovery value of 1 night of good quality, extended (ad lib) sleep following extreme modifications and restrictions in work/rest schedules (4,9,14). In this study the student and instructor pilots averaged more sleep on the weekends (Friday and Saturday nights) than they did during the work week. How much of this extra sleep was physiologically compensatory for sleep deficit accumulated during early-schedule duty weeks and how much resulted from simply sleeping-in cannot be precisely determined. However, some of the hours slept on the weekends were apparently of a catch-up nature, as the average time slept was greater after a week on the early schedule than on the late schedule.

CONCLUSIONS

As indicated by both sleep logs and subjective fatigue reports, the UPT schedule of alternating weekly between early-morning and late-morning report times causes both student and instructor pilots to feel less than completely rested at the start of their early-morning duty days. The level of fatigue reported appears to be modest, particularly for the time-of-day, and not of dramatic operational impact except for the fact that this is a learning situation for the student pilots. Significant performance impairment has seldom been detected for active, well-learned tasks as a result of 1-2 hours per night sleep reduction. For new, unmastered tasks and well-learned but passive "watchkeeping" tasks, however, performance deterioration has been found to sometimes occur. The elevated fatigue at the beginning of each early-schedule day suggests that the pilots may have less reserve capacity and may have to try harder to maintain acceptable levels of attention and performance than when on the late schedule. This applies especially to student pilots whose flying skills are not well learned, integrated, and automatic.

The alternating weekly schedule impacts on the pilots in two ways. First, the schedule requires weekly readjustment of sleep and duty schedules. In most cases, the alternating schedule is much more demanding and tiring than is permanent assignment to an uncommon work schedule. The literature-base indicates that some degree of adaptation and adjustment would occur after several consecutive weeks of permanent assignment to the early schedule. Personal, family, and, to some extent, physiological function would better stabilize to accommodate the duty schedule. However, given the requirement for both day and night flight training in all phases of UPT and the fact that the pilots would revert to more customary schedules on days off, this does not appear to be a feasible means of reducing schedule-related pilot fatigue. (Although documentation cannot be located, the authors have been told of a study conducted at Williams AFB, Arizona, in 1978. Training flights in a T-37 squadron rotated between the early and late schedules every 2 weeks. This schedule was well accepted for a month, but resulted in several complaints of marked fatigue when on the early schedule during the second month.)

Second, the pilots on the early-morning schedule acquire less than desirable amounts of nightly sleep because they are required to advance their arising times to much earlier than normal. This earlier time contributes as much, or more, to the fatigue reported at the beginning of each early-morning day as does the reduced amount of hours slept. In an attempt to compensate, the pilots advance their bedtimes; but this maneuver does not completely compensate, especially for a week's time. In fact, advancing a sleep period has been shown to be more stressful than delaying a period (2). Our inability to evaluate progressive changes in fatigue scores within each day prohibited a more thorough evaluation of UPT schedule impact. However, subjective fatigue scores and established daily psychophysiological patterns indicate that starting the UPT early-morning duty day 1-1 1/2 hours later (0630-0700) might considerably reduce early-morning pilot fatigue and sleepiness.

RECOMMENDATIONS

The findings and conclusions from this study are of a preliminary nature. Because the data were incomplete, liberties have been taken that would have been inappropriate for more refined statistical analyses.

At minimum, the findings from this evaluation provide empirical data for describing to both student and instructor pilots the importance of acquiring adequate rest and sleep. The greater stress of the early-week schedule should be emphasized.

If operationally feasible, starting the early-week duty day at 0630-0700 may reduce early-morning pilot fatigue and sleepiness.

Future evaluations should concentrate on in-depth data collection from 20-25 pilots who are dedicated to the study, thereby minimizing missing data and permitting accurate description of both between-day and within-day patterns of response.

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